

Literature 1.0

Women in Computer Science: Experience, Motivation and Culture

Fisher et al. (1997) conducted a study to understand women's attachment and detachment from computer science and to find ways for Carnegie Mellon University (CMU) to intervene at the undergraduate level in favor of gender equity in computer science. The study found that women are underrepresented in computer science at CMU and in other higher education institutions across the nation. The study also found that a significant gap exists between male and female prior experience in computer science, with men being more prepared for their computer science courses than women. However, this gap does not necessarily translate into better performance in the classroom. Female students often report lower confidence levels in their computing abilities and experiences compared to their male counterparts. Women's interest in computer science often evolves over time, rather than being an immediate, intense interest as it is for men. Women tend to be more focused on the practical applications of computer science and see it as a tool to use within a broader context of education, medicine, communication, art, and music. Women in computer science face various barriers, including a lack of role models, gender-insensitive course materials, and a hostile climate in some classrooms.

One of the key findings of Fisher et al. (1997) is the significant gap in prior experience between male and female students entering computer science courses. Men often have more exposure to computing before college, which gives them a head start in their courses. This disparity, however, does not necessarily translate into better academic performance. Interestingly, despite similar or even better performance, female students frequently report lower confidence levels in their computing abilities compared to their male counterparts. This confidence gap can be detrimental, influencing their overall experience and persistence in the field.

Supporting this, Scragg and Smith (1998) found that women often face specific barriers that hinder their participation in computer science programs. These barriers include the perception of computer science as a "masculine" field, the lack of female role models, and a culture of competitiveness and discrimination within the classroom environment. Addressing these barriers is crucial for improving gender equity in computer science.

To address these challenges and barriers, the literature suggests promoting inclusivity, providing educational resources, creating supportive communities, addressing biases and barriers, and encouraging role models and mentorship. Organizations can create more inclusive and productive environments that empower women in IT and computer science by following these recommendations.

The dynamics of women's engagement with computer science were rigorously examined to identify strategies for enhancing gender equity at the undergraduate level. This study highlighted the significant underrepresentation of women in computer science at CMU and similar institutions nationwide. One critical finding was the disparity in prior experience between male and female students, with men generally entering their courses with more extensive preparation. However, this disparity did not correlate with superior academic performance by male students.

The research also noted that female students often report lower confidence in their computing skills compared to their male counterparts. Unlike men, whose interest in computer science tends to be immediate and intense, women's interest frequently develops more gradually. Moreover, women often approach computer science through its practical applications, considering it a valuable tool in diverse fields such as education, medicine, communication, art, and music.

Several barriers were identified that hinder women's participation in computer science, including the absence of role models, gender-biased course materials, and occasionally hostile classroom environments. To mitigate these challenges, the literature recommends fostering inclusivity, providing tailored educational resources, creating supportive communities, addressing inherent biases, and promoting mentorship and role models. By adopting these strategies, institutions can cultivate more inclusive and productive environments, thereby empowering more women to thrive in IT and computer science.

Gender and engineering: Developing actions to encourage women in tech

In the last decades the number of women who choose to study careers related to Science, Technology, Engineering and Mathematics (STEM) has diminished. Since this situation spreads to the next stage, i.e. to working life, consequently the women are underrepresented in the global technology workforce. This is both a societal concern and a major workforce problem, given the critical shortage of skilled technology professionals faced by many enterprises. According to ISACA's 2017 Women in Technology Study [1], many challenges still need to be addressed to solve this problem from a persistent gender bias in the workplace to continued pay gaps and a lack of female mentors. Five of the most common obstacles that women encounter are: lack of mentors, lack of female role models in the field, gender bias in the workplace, unequal growth opportunities compared to men, unequal pay for the same skills.

One large-scale study found that after about 12 years, approximately 50 percent of women had left their jobs in STEM fields—mostly in computing or engineering (Glass, Sassler, Levitte & Michelmore, 2013) [3]. Evidence suggests that workplace conditions, a lack of access to key creative roles, and a sense of feeling stalled in one's career are some of the most significant factors contributing to female attrition from the tech field. There are exceptions, very encouraging ones this study sheds light on. Asian countries, especially the case of Malaysia with a more balanced percentage, where half of the people working in technology are women, Studies suggest that Malaysian women see IT careers as a way of working instead of a status symbol. They emphasize two values that have propitiated this situation, a safe working environment and the strong belief of previous generations that information and communications technologies (ICT) would be a sector with many job opportunities, with which parents have encouraged their children, regardless of sex.

Since 1983, there have been numerous reports of problems with education in science and mathematics [11], as well as recommendations for improvements in education such as using active learning, participating in projects and implementing presence of mentors. But these measures are not aimed at improving the situation of students with a smaller presence in these areas such as, women and other minorities. In this regard, women can be considered a minority within the context of STEM studies due to their lack of presence, not as minorities in society [12].

According to Buquet Corleto (2011) [13] incorporating gender studies into the curricula is considered as a factor that favors the institutionalization of the gender perspective in institutions of higher education and focuses on two complementary but with different scope objectives. Such a course directly impacts on the academic preparation of the young people in training by providing new theoretical and methodological elements for the understanding of social reality.

Why So Few? Women in Science, Technology, Engineering, and Mathematics

The number of women in science and engineering is growing, yet men continue to outnumber women, especially at the upper levels of these professions. In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave high school prepared to pursue science and engineering majors in college. Yet fewer women than men pursue these majors. Among first-year college students, women are much less likely than men to say that they intend to major in science, technology, engineering, or math (STEM). By graduation, men outnumber women in nearly every science and engineering field, and in some, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20 percent of bachelor's degrees. Women's representation in science and engineering declines further at the graduate level and yet again in the transition to the workplace. Drawing on a large and diverse body of research, this report presents eight recent research findings that provide evidence that social and environmental factors contribute to the under-representation of women in science and engineering.

Academic research on this topic is prolific, with three themes emerging from the literature. First, the notion that men are mathematically superior and innately better suited to computer science and IT fields than women are, remains a common belief, with a large number of articles addressing cognitive gender differences as an explanation for the small numbers of women in the tech space. A second theme revolves around girls' lack of interest in computer science and Information technology. A third theme involves the workplace, with issues ranging from work-life balance to bias. Majority girls and women report that they are "just not interested" in the field of study. A study showed that from early adolescence, girls express less interest in math or science careers than boys do (Lapan et al., 2000; Turner et al., 2008). Even girls and women who excel in mathematics often do not pursue STEM fields. In studies of high mathematics achievers, for example, women are more likely to secure degrees in the humanities, life sciences, and social sciences than in math, computer science, engineering, or the physical sciences; the reverse is true for men (Lubinski & Benbow, 2006).

Women in computer science and IT fields can experience bias that negatively influences their progress and participation. Although instances of explicit bias may be decreasing, implicit bias continues to have an adverse effect. Implicit biases may reflect, be stronger than, or in some cases contradict explicitly held beliefs or values. Therefore, even individuals who espouse a belief of gender equity and equality may harbor implicit biases about gender and, hence, negative gender stereotypes about women and girls in science and math (Valian, 1998). Nosek et al. (2002a) found

that majorities of both women and men of all racial-ethnic groups hold a strong implicit association of male with science and female with liberal arts.

Women In Tech: The Facts

The literature on empowering women in IT and computer science highlights the importance of providing support, resources, and opportunities for women to excel in tech-related fields. The literature emphasizes that women's participation in technology is essential for innovation, productivity, and the company's bottom line. However, women face several challenges, including imposter syndrome, gender inequality, and underrepresentation in the tech industry. The literature suggests that promoting inclusivity, providing educational resources, and creating supportive communities can help address these challenges and advance the goal of empowering women in technology careers.

Several organizations and initiatives are dedicated to this cause, such as Women in Tech® Global, Women in Technology (WIT), Women Who Code, and others. These organizations offer various programs, including mentoring, networking, career support, and advocacy to help women thrive in technology careers. The literature also highlights the importance of addressing biases and barriers that hinder women's advancement in the tech industry. Biases such as unconscious bias, stereotype threat, and tokenism can pose problems for all workplaces, but they can be even more pronounced in "majority-group" environments, as is the case in many tech companies or departments. In such an environment, systems emerge to reflect and meet the needs of the majority-group population. However, if these policies or systems do not change with the times, they can inadvertently inhibit the success of members who differ from the majority. The literature also identifies several barriers to retention and advancement of underrepresented groups in technical fields. These barriers include managerial relationships, isolation, performance evaluations and promotion, and competing life responsibilities. Technical managers often have less training or expertise when it comes to effectively managing people, and a lack of sponsors and informal networks makes it more difficult for women to navigate "unwritten" company rules and norms. Many technical women report feeling stalled in their careers, and in performance evaluation, women receive advice that they need to be "less abrasive" or should "tone it down" much more frequently than do men.

To address these challenges and barriers, the literature suggests taking an ecosystem approach to change. This approach involves enlisting top leadership support, educating managers, and collecting appropriate data to lay the groundwork for informed change efforts. It is also important to make explicit the important role that male (or majority-group) allies and advocates can play in accelerating change. By following these recommendations, organizations can create more inclusive and productive environments that empower women in IT and computer science.

Why women avoid computer science

The literature review "Why Women Avoid Computer Science" by Haney (2001) discusses the underrepresentation of women in computer science and the potential reasons behind it. The author challenges common speculations, such as math anxiety, and offers a different perspective. Haney

suggests that the ill-defined nature of computing, as opposed to the precision of mathematics, may be a factor driving women away from computer science. The author also discusses the influence of the microcomputer revolution on the gender composition of computer science, proposing that the field became less attractive to women as it shifted from a focus on software to hardware tinkering. Additionally, the review addresses the perceived lack of professionalism in the field and the difficulty of the computer science curriculum as factors that may deter women. Haney concludes by proposing changes to make computer science more appealing to women, such as teaching programming as a form of logic, minimizing reliance on complex software tools, and emphasizing the determinate nature of computing.

Women are about a third as likely as men to major in computer science and information technology. Progress towards achieving the equal participation of women as well as men at the undergraduate level has been slow. To a large extent other technical oriented departments face the same recruitment and retentions problems when it comes to females taking courses.

Some common problems – discriminatory behavior patterns that create an unsupportive classroom experience, differences in how students assess their own performance in correlation to gender, scarcity of role models(females), no sustained supportive peer communities.

Other specific problems – the level of computing experience that students have prior their enrollment differs greatly between genders. The culture that develops around the computer science department is often not attractive to women. It is more male friendly; therefore, women tend to stay away from male dominated spaces.

Numbers also play an important role in this case, over the years, most computer science programs focus on the disproportionately small percentage of women graduating with computer science degrees. While low percentages are ultimately a matter of concern, it is often more useful to focus on the number of women enrolled in computer science programs. As outlined in the preceding section, one of the major barriers to women's participation in computer science is the difficulty of creating a critical mass of women within an institution. The ability to develop such a critical mass is largely a function of the number of women available to become part of that community. Producing more women with computer science degrees is also important over the longer term, because it increases the pool of qualified women who can serve as mentors for future generations.

A surprising number of writers attribute the decline in the number of computer science degrees largely to the result of measures or explicit steps taken by the computer science department to reduce the number of students being enrolled. These measures include imposing requirements that are quite strict for admissions into computer science, adding new required courses in mathematics, and transforming introductory courses into filters designed to limit entry into the field. Such strategies have a disproportionately negative effect on enrollment by women and minorities.

Barriers to Women in Undergraduate Computer Science

The underrepresentation of women in computer science is a persistent issue, with significant disparities observed worldwide. Scragg & Smith's (1998) study delves into this issue at SUNY Geneseo, a university facing a similar trend. Their research sheds light on the specific barriers hindering women's participation in computer science programs and proposes strategies to address them. This paper explores the barriers faced by women in undergraduate computer science and aims to understand their attachment and detachment from the field.

A multitude of factors have been identified as potential barriers for women in computer science:

The perception of computer science as a "masculine" field, often associated with introverted, socially awkward individuals, can discourage women from pursuing it. The historical and ongoing underrepresentation of women in computer science creates a dearth of female role models, making the field seem less attainable for young women. A culture of competitiveness, lack of collaboration, and sometimes discriminatory attitudes within computer science classrooms and departments can alienate women. Insufficient support systems, such as mentoring programs or peer networks, can leave women feeling isolated and unsupported in their pursuit of computer science.

This research reveals that the primary challenge lies in recruitment, not retention. They observed that few women initially express interest in majoring in computer science, even among those enrolled in introductory courses. This contradicts the common assumption that women primarily leave the field due to negative experiences within the major.

Esther Shein discusses that women in computer science still face significant challenges despite making strides in the field. The paper emphasizes that barriers such as gender biases, lack of role models, and work-life balance issues continue to hinder the progress of women in technology (Shein, 2023).

L. Blum's study on the Carnegie Mellon experience shows a notable increase in the percentage of women in the undergraduate computer science program, from 7% in 1995 to approximately 40% in the fall of 2000. This improvement is attributed to specific initiatives and programs designed to attract and retain women in the field, such as creating a supportive community and addressing the curriculum to make it more inclusive.

A study by D. Cordeiro et al. reveals a significant reduction in the proportion of women in postgraduate teaching in Computer Science in Brazil over the last 15 years. Despite efforts to encourage women's participation in technology-related areas, the decline suggests persistent structural and cultural barriers that need to be addressed to improve women's representation in higher education and academic positions in computer science (Cordeiro et al., 2020).

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